**Public health implications**

- An AIDS control programme was established in Uganda in 1989 in response to high rates of HIV infection
- In 1990 most subjects in Rakai district had attended an AIDS rally in the past year and were aware of the risk factors for HIV infection
- The proportion of subjects having two or more sexual partners in the past year increased from 8·9% in 1989 to 12·3% in 1990
- The incidence of HIV infection was 2·1/100 person years
- The control programme has so far not reduced transmission of HIV in Rakai. More priority should be given to educating people in rural areas

population with a high prevalence of HIV infection even moderate sexual activity (one partner reported in the previous year) is associated with substantial risk of seroconversion (2·8/100 person years).

Knowledge of AIDS is almost universal, and most subjects had attended an AIDS education rally during the period of observation. It is therefore disturbing that the proportion of all adults admitting to multiple sexual partners in the previous year increased significantly from 8·9% to 12·3% between 1989 and 1990. Although the increase may reflect greater candour at reinterview, the data do not suggest any reduction in high risk behaviour. Since 1987 Uganda has mounted one of the most extensive AIDS education programmes in Africa, and the Rakai project implemented community interventions in 1989. Although incidence may have been even higher without the educational interventions, existing programmes have not curbed transmission. These findings reflect the difficulties of implementing effective interventions in communities and underline the urgent need for better strategies. Furthermore, the high HIV incidence found in remote rural villages and in people with even moderate reported levels of sexual activity indicate that identification of high risk populations or groups may become increasingly difficult. Because over 70% of the African population lives in rural areas[8] greater priority should be given to these vulnerable communities.

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# Effectiveness of bicycle helmets in preventing head injury in children: case-control study

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## Abstract

***Objective***—**To examine the risk of injury to the head and the effect of wearing helmets in bicycle accidents among children.**

***Design***—**Case-control study by questionnaire completed by the children and their carers.**

***Setting***—**Two large children's hospitals in Brisbane, Australia.**

***Subjects***—**445 children presenting with bicycle related injuries during 15 April 1991 to 30 June 1992. The cases comprised 102 children who had sustained injury to the upper head including the skull, forehead and scalp or loss of consciousness. The controls were 278 cyclists presenting with injuries other than to the head or face. A further 65 children with injuries to the face were considered as an extra comparison group.**

***Main outcome measures***—**Cause and type of injury, wearing of helmet.**

***Results***—**Most children (230) were injured after losing control and falling from their bicycle. Only 31 had contact with another moving vehicle. Children with head injury were significantly more likely to have made contact with a moving vehicle than control children (19 (19%) *v* 12 (4%), P<0·001). Head injuries were more likely to occur on paved surfaces than on grass, gravel, or dirt. Wearing a helmet reduced the risk of head injury by 63% (95% confidence interval 34% to 80%) and of loss of consciousness by 86% (62% to 95%).**

***Conclusions***—**The risk of head injury in bicycle accidents is reduced among children wearing a helmet. Current helmet design maximises protection in the type of accident most commonly occurring in this study. Legislation enforcing helmet use among children should be considered.**

## Introduction

Childhood bicycle injuries are one of the main reasons for presentation to paediatric emergency departments in Brisbane, Australia. Admission to hospital and death from bicycle related trauma are usually due to head injury.[1] Several studies of bicycle safety helmets report an associated reduction of head injuries,[2,3] and in the only case-control study the risk of head injury was significantly reduced if a helmet was worn.[3] Wearing helmets became mandatory in Queensland, Australia, in July 1991. We examined the risk of upper head injury or loss of consciousness associated with helmet wearing among children.

## Subjects and methods

The study was conducted between 15 April 1991 and 30 June 1992 at the Royal Children's and Mater Misericordiae Children's Hospital, the two main children's hospitals in Brisbane. Children attending the emergency departments were ascertained by specific flagging by triage staff. We also carried out daily checks of triage books, patient presentation lists, and hospital wards, as well as computer searches of hospital records. Four hundred and forty five children aged 14 years or less had bicycle related injuries during the study period. A search of death certificate files showed one death of a cyclist who had not presented to the reference hospitals and was not therefore included in the study. Data collection started two and a half months before wearing helmets became compulsory (54 children). The case group comprised the 102 children with injuries to the upper head area, the region potentially protected by a bicycle helmet, including injuries to the skull, forehead, and scalp or loss of consciousness. To determine the protective effect of helmets against loss of consciousness, a subgroup of 41 children who lost consciousness was considered separately.

The control group consisted of the 278 cyclists who were treated for injuries other than to the upper head or face. The 65 children with injuries to the face were used as an additional comparison group. Assuming a two sided hypothesis and available data on 102 cases and 278 controls the relative odds of a head injury of at least 2·0 among non-helmet wearers would be able to be detected at 95% significance with 80% power, assuming that 47% of controls wore helmets.

A self administered questionnaire was completed by the child and his or her carer. Information was recorded on the factors leading to the accident, including bicycle malfunction, riding incorrectly, poor road conditions (for example potholes), avoiding objects including pedestrians, and contact with other moving or stationary objects. The surface on to which the child fell was also recorded. The degree of damage to the bicycle was used as a proxy to assess severity of impact.[3]

Injuries were defined by the clinician using a standard Queensland injury surveillance prevention project form. Ownership and use of a bicycle helmet at the time of the accident were recorded. We grouped children according to the number of years of education of the most educated parent to reflect the levels of lower secondary (10 years), upper secondary (12 years), and tertiary training in Queensland.

Non-responders were followed up within three weeks of the injury. In a concurrent repeatability study, we reinterviewed a random sample of 30 subjects by telephone within three weeks of the initial self administered questionnaire. The data were found to be almost identical for all variables.

The relation of injuries to the upper head or loss of consciousness to helmet wearing and other variables was investigated by $\chi^2$ contingency tests. To produce final risk estimates, unconditional logistic regression models of the log odds of injury to the upper head or loss of consciousness were adjusted for the potential confounding effects of sex, age, hospital, parental education, the main cause of the accident, contact with a moving vehicle or a stationary object, and the severity of the impact based on the repair needs of the bicycle.[4]

Controls could have been less likely to hit their heads in the accident.[3] We therefore also compared the 102 children with injuries to the upper head (the case group) to a second control group of 65 children with injuries to the face but no concurrent injury to the upper head, as both groups had struck their head in the accident.

Brisbane is a subtropical city with a population of about 1·3 million. At the 1986 census, the workforce comprised 30% professional, paraprofessional, and managerial workers; 55% tradespeople, clerks, or sales related workers; and 14% manual labourers.[5] There were about 950 000 vehicles registered on Brisbane roads in 1991.

## Results

Three quarters of those injured in bicycle accidents were boys. This proportion was also reflected among children with upper head injury and those who lost consciousness (table I). Age was not significantly associated with upper head injury. More than half of injuries were reported to be caused by faulty riding, and 46 resulted from a faulty bicycle (table II). Contact with another moving vehicle was reported by 31 children. Significantly more children with upper head injury ($P<0·001$) had accidents involving contact with another moving vehicle (table II). More injuries to the upper head occurred when the children fell on paved surfaces than on gravel, dirt, or grass ($P=0·012$). Bicycles belonging to children who had sustained an upper head injury were significantly more likely to require repair than those belonging to controls ($P<0·001$), and a larger proportion were beyond repair in the group who lost consciousness compared with the controls ($P<0·001$).

TABLE I—*Demographic characteristics of 102 children with head injury (cases), the subset of 41 who lost consciousness, and 278 with other bicycle related injury (controls)*

| | No (%) of controls | No (%) of children with upper head injury | No (%) of children who lost consciousness |
|---|---|---|---|
| Hospital: | | | |
| Mater Misericordiae | 179 (64) | 45 (44) | 19 (46) |
| Royal Children's | 99 (36) | 57 (56) | 22 (54) |
| | | P<0·001* | P=0·026 |
| Sex: | | | |
| Male | 211 (76) | 79 (78) | 35 (85) |
| Female | 67 (24) | 23 (22) | 6 (15) |
| | | P=0·752 | P=0·178 |
| Age (years): | | | |
| 0-4 | 30 (11) | 5 (5) | 1 (2) |
| 5-9 | 100 (36) | 47 (46) | 17 (42) |
| 10-14 | 148 (53) | 50 (49) | 23 (56) |
| | | P=0·081 | P=0·233 |
| Parents' highest level of education (years)† | | | |
| ≤10 | 73 (32) | 22 (26) | 10 (30) |
| -12 | 22 (10) | 12 (14) | 1 (3) |
| >12 | 135 (59) | 50 (60) | 22 (67) |
| | | P=0·387 | P=0·420 |

*$\chi^2$ test compared with control group.
†Data not available for all children.

TABLE II—*Characteristics of bicycle accidents in Brisbane children**

| | No (%) of control children (n=278) | No (%) of children with upper head injury (n=102) | No (%) of children who lost consciousness (n=45) |
|---|---|---|---|
| Main cause: | | | |
| Faulty riding | 174 (64) | 56 (55) | 21 (51) |
| Faulty bicycle | 37 (14) | 9 (9) | 7 (17) |
| Faulty road | 18 (6) | 12 (12) | 4 (10) |
| Other† | 43 (16) | 24 (24) | 9 (22) |
| | | P=0·063‡ | P=0·602 |
| Surface: | | | |
| Paved | 143 (53) | 70 (69) | 29 (71) |
| Gravel | 27 (10) | 12 (12) | 3 (7) |
| Dirt | 18 (7) | 5 (5) | 3 (7) |
| Grass | 57 (21) | 7 (7) | 3 (7) |
| Other | 24 (9) | 7 (7) | 3 (7) |
| | | P=0·012 | P=0·206 |
| Hit a stationary object: | | | |
| Vehicle | 7 (3) | 10 (10) | 6 (15) |
| Post, fence | 18 (7) | 4 (4) | 0 (0) |
| Kerb, gutter | 30 (11) | 21 (21) | 8 (19) |
| Other | 46 (17) | 14 (14) | 4 (10) |
| Contact with a moving vehicle: | | | |
| Yes | 12 (4) | 19 (19) | 7 (18) |
| No | 260 (96) | 82 (81) | 33 (82) |
| | | P<0·001 | P<0·001 |
| Bicycle needed repair: | | | |
| No | 189 (77) | 53 (55) | 16 (42) |
| Yes | 57 (22) | 34 (35) | 17 (45) |
| Beyond repair | 3 (1) | 9 (9) | 5 (13) |
| | | P<0·001 | P<0·001 |

*Some respondents did not answer all the questions.
†Included avoided obstacles and 20 children who attributed their accident to faulty driving of another vehicle.
‡$\chi^2$ test compared with control group.

Ownership of helmets was similar for the case and control groups (71% of children with upper head injuries, 66% with loss of consciousness and 77% of controls; table III). Most children who were wearing a helmet at the time of the accident had hard shell helmets. Significantly fewer children with head injury were wearing a helmet at the time of the accident compared with control subjects (P=0·007). Only a fifth of the children who lost consciousness were wearing a helmet at the time of the accident (P=0·002).

The crude protective effect of wearing a helmet against upper head injuries remained after adjustment for potential confounding effects. We did not adjust for the surface on which the child fell as the data merely reflected responses to contact with a stationary object. Risk of injuries to the upper head was 2·7-fold (95% confidence interval 1·5 to 4·9) higher among non-helmet wearers than among helmet wearers. For loss of consciousness the risk was 7·3-fold higher (2·6 to 20·4) among non-helmet wearers than among helmet wearers. This translates to a reduction in risk among helmet wearers of 63% (34% to 80%) for upper head injuries and 86% (62% to 95%) for loss of consciousness.

Thirty three (51%) of the 65 children who had an injury to the face but not concurrent injury to the upper head were wearing a helmet. When these children were used as a control group the reduction in risk of injury to the upper head among helmet wearers was 51% (−10% to 78%).

TABLE III—*Wearing of helmets among children who had bicycle accidents**

| | Controls Number (%) | Upper head injury Number (%) | Loss of consciousness Number (%) |
|---|---|---|---|
| Owned a helmet: | | | |
| Yes | 200 (77) | 69 (71) | 25 (66) |
| No | 60 (23) | 28 (29) | 13 (34) |
| | | P=0·259† | P=0·136 |
| Wearing helmet at time of accident: | | | |
| Yes | 126 (47) | 31 (32) | 8 (20) |
| No | 140 (53) | 67 (68) | 31 (80) |
| | | P=0·007 | P=0·002 |
| Type of helmet worn: | | | |
| No shell | 11 (4) | 1 (1) | 0 (0) |
| Thin shell | 3 (1) | 1 (1) | 0 (0) |
| Hard shell | 88 (34) | 27 (28) | 8 (20) |
| Not approved | 16 (6) | 1 (1) | 0 (0) |

*Some subjects did not answer all the questions.
†Significance of $\chi^2$ test statistic for the association between each variable and case-control status.

## Discussion

Helmet wearing was significantly associated with a reduced risk of upper head injury and loss of consciousness. The reduction in risk persisted after adjustment for the confounding effects of age, sex, the main cause of the accident, contact with other objects including motor vehicles, the road surface, and the severity of damage to the bicycle.

The controls used in this study were similar to the emergency room controls used by Thompson *et al.*[3] They reported a significant increase in risk of upper head injury and loss of consciousness for those not wearing helmets compared with the population based on the emergency room control group. The point estimates in the present study were consistent with the findings for the emergency room control group of Thompson *et al.*[3] An emergency department control group has some limitations. Although the legislation enforcing helmet wearing in Queensland did not include penalty provisions during the study, children not wearing helmets who had a minor head injury may have been less likely to present to hospital. This would underestimate the effectiveness of helmets. We believe such a bias is unlikely, particularly among children needing admission to hospital for loss of consciousness. Other sources of selection bias relating to the emergency department control group have been discussed by Thompson *et al*,[3] but are unlikely to affect the direction of the result. For example, cyclists who had not attended hospital after striking but not injuring their head when wearing a helmet would strengthen the observed association between helmets and a reduced risk of upper head injury had they been included in the study. Similarly, reduction in the estimated risk of upper head injury would have been greater if cyclists wearing helmets who did not have head injuries were more likely than non-helmet wearers to attend hospital.

When the analysis was restricted to children who had hit their head in the accident, the reduction in risk associated with helmet wearing was similar to that found for the sample as a whole. This suggests the reduction in risk of upper head injury was not due to cases having accidents which were more likely to damage the head. We did not directly measure risk taking behaviour, an important potential confounding variable for bicycle related injuries. However, the study population was limited to children who had been injured in a bicycle accident. We surmise that this group, regardless of site of injury were more likely than the general population to be risk takers. Confounding was controlled at least in part by this restriction. In addition we adjusted for factors potentially related to risk taking including sex, type of accident, its severity, and the involvement of another moving vehicle.

Although some people claim that motorists cause most accidents involving cyclists,[6] our study indicates that the oppopsite is the case for children in Brisbane. The British Standard 6863 for cycle helmets,[7] (the Australian Standard[8] is similar) states they are designed to protect "in the kind of accident in which the rider falls onto the road without other vehicles being involved." These were the most commonly occurring accidents in this study.

The association between wearing helmets and reduced risk of head injury among child bicyclists is now compelling. The high level of compliance with recent helmet wearing legislation[9] is likely to help reduce further the incidence of bicycle related head injury.[10] The crucial question not answered by this study is whether there is a cause and effect association or whether influences leading to non-helmet wearing are associated with other risk taking behaviour. Prospective cohort studies in populations with high compliance with compulsory helmet wearing will give insight into these issues.

**Public health implications**

- Bicycle accidents are a common cause of injury in children
- In this study most injuries were caused by losing control of the bicycle and did not involve a moving vehicle
- Bicycle helmets reduced the risk of upper head injury by 63% and loss of consciousness by 86%
- Children should be encouraged to wear cycle helmets

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# Recent treatment with $H_2$ antagonists and antibiotics and gastric surgery as risk factors for salmonella infection


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Experimental evidence shows that gastric acid protects against enteric infections,[1,2] and patients who have had gastric surgery seem to be more susceptible to salmonella infection.[3,4] Whether $H_2$ antagonists are also associated with salmonella infection is not known, although diarrhoea is a recognised side effect. Statutory notifications of salmonella infection have increased in recent years and the use of $H_2$ antagonists has become widespread, suggesting that suppression of acid by these drugs may have been contributory. We conducted a case-control study to assess whether $H_2$ antagonists are associated with salmonella infection.

## Patients, methods, and results

From March 1990 to September 1992, 218 notified cases of salmonella infection, confirmed by faecal culture, occurred in people aged $\geqslant 45$ in the Nottingham area. Thirty cases were excluded because the patient was non-resident (4), the patient's general practitioner declined to participate (19), or the notes were unobtainable (7). Thus 188 cases (86 in men) were studied. Controls were identified as the next two patients in the practice records system matched for age (within five years) and sex.

Data on previous gastric surgery; drugs prescribed in the preceding year; and whether $H_2$ antagonists, hydroxocobalamin, antibiotics, and corticosteroids had ever been prescribed were extracted from the patients' records. Only drugs that the patients had begun taking before the onset of salmonella infection were noted. Data were analysed by conditional logistic regression with the EGRET package, and relative risks were approximated by odds ratios. The number of attributable cases was calculated from the adjusted relative risks.

Treatment with $H_2$ antagonists in the past month was associated with a twofold increased risk of salmonella infection, and recent antibiotic treatment was associated with a 50% increased risk; previous gastric surgery was associated with a fivefold increased risk (table). Much of this increased risk was in patients aged over 65. In three cases and one control gastric surgery had been performed in the five years before infection. Analyses by sex showed the same associations. No associations were seen with corticosteroid or hydroxocobalamin treatment or any other class of prescription drug. The total estimated number of notified cases attributable to an iatrogenic cause was 32 (gastric surgery 15, $H_2$ antagonists 9, antibiotics 8).

*Relative risks for associations with salmonella infection**

| Exposure | Cases (n=188) | Controls (n=376) | Relative risk (95% confidence interval): All ages, Unadjusted | All ages, Adjusted | Ages 45-64 (124 cases) adjusted | Age 65+ (64 cases) adjusted |
|---|---|---|---|---|---|---|
| Gastric surgery | 18 | 7 | 5·6 (2·1-15·2)† | 4·5 9-11·0)‡ | 2·0 (0·5-8·3) | 8·8 (2·4-32·3)‡ |
| $H_2$ receptor antagonists: | | | | | | |
| In past month | 16 | 14 | 2·4 (1·1 to 5·4)§ | 1·9 (0·9 to 4·0) | 1·1 (0·4 to 3·0) | 4·6 (1·1 to 19·3)§ |
| In past year | 19 | 22 | 1·8 (0·9 to 3·6) | 1·5 (0·8 to 2·9) | 1·0 (0·4 to 2·6) | 2·6 (0·8 to 8·7) |
| Ever | 27 | 38 | 1·5 (0·9 to 2·6) | 1·3 (0·8 to 2·2) | 1·1 (0·5 to 2·2) | 1·6 (0·7 to 4·0) |
| Ever (excluding past month) | 11 | 24 | 1·0 (0·4 to 2·1) | 0·9 (0·4 to 2·0) | 1·1 (0.4 to 2·9) | 0·8 (0·2 to 3·0) |
| Antibiotics: | | | | | | |
| In past month | 17 | 20 | 1·8 (0·9 to 3·7) | 1·8 (0·9 to 3·8) | 1·7 (0·9 to 2·4) | 6·3 (1·1 to 34·8)§ |
| In past year | 74 | 116 | 1·5 (1·0 to 2·1)§ | 1·4 (1·0 to 2·1) | 1·5 (0·9 to 2·4) | 1·3 (0·6 to 2·7) |
| In past year (excluding past month) | 57 | 96 | 1·4 (0·9 to 2·1) | 1·5 (1·0 to 2·3) | 1·8 (1·0 to 3·1)§ | 1·0 (0·5 to 2·3) |
| Ever (excluding past month) | 148 | 309 | 1·0 (0·6 to 1·7) | 0·9 (0·5 to 1·7) | 1·1 (0·6 to 2·2) | 0·3 (0·1 to 1·4) |

*Adjusted for gastric surgery, $H_2$ antagonist treatment, antibiotic treatment, and other drug use.
†$P=0·00003$.
‡$P=0·001$.
§$P<0·05$.

### Comment

Our results confirm that gastric surgery predisposes to clinical salmonella infection[4] and show the same for $H_2$ antagonists. Our finding that current users, but not former users, of $H_2$ antagonists were at increased risk suggests that the relation is causal. The severity of infection has been related to the size of the infecting dose. These risk factors are likely to increase the severity of infection by reducing the gastric killing of ingested organisms because of reduced acidity and more rapid transit after gastric surgery.

Salmonella infection has been reported anecdotally in people taking proton pump inhibitors, but none of the cases or controls had taken these drugs during the study period. We used treatment with hydroxocobalamin as a proxy for the achlorhydria associated with pernicious anaemia, but as only three cases and three controls had taken hydroxocobalamin, no definitive comment on a causal link can be made.

Our results also suggest that antibiotics increase the risk, or possibly the severity, of salmonella infection, especially in elderly people, as was reported from the United States.[5] Antibiotics may predispose to infection by changing the flora in the bowel. More work is needed to determine how long the risk persists after treatment with antibiotics.

Our data suggest that the above factors are most important in people over 65. This may reflect the reduction in the secretion of gastric acid that occurs with age interacting with other predisposing factors.[2]


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